Passive Facial Recognition

Intro

INTERNATIONAL BIOMETRIC PERFORMANCE CONFERENCE
Evaluation and Performance of Biometric Technologies
May 3 – 5, 2016: Gaithersburg, MD

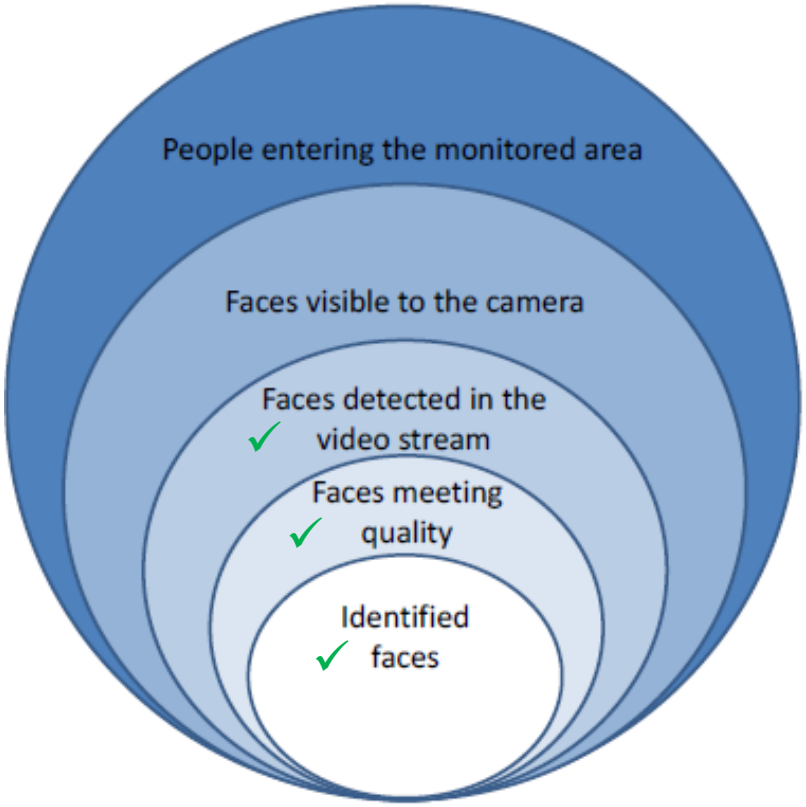
Findings from 4 Passive (Unconstrained) Facial Recognition Pilots

- **Border Management x 2**
- **Retail (Shopping Center)**
- **Gambling (Lottery Kiosk)**

Passive Facial Recognition
Background

Common across the 3 pilots:

- Detect human face(s)
- Crop face(s)
- Face Tracking / Singulation
- Feature Extraction
- Comparison



Passive Facial Recognition

Use Case #1 – Borders

The objective of this Trial was to deploy a simple Passive FR system in the BAA environment to gain a better-understanding of the capabilities of the solution and to assess its potential for use in various business scenarios:

1. Passenger Timing
2. Face Watchlisting
3. Undocumented Passenger Identification
4. Border Pre-Clearance

These scenarios represent the current areas of mutual interest; however, the underlying technology capabilities can be applied to any scenario where identification of individuals is desired

Passive Facial Recognition

Use Case #1- Borders

1. The "**Passenger Timing**" scenario aims to establish average travel times between two (or more) points, by identifying individuals as they pass each location, and timestamping each "appearance" against a synchronised time source – to be used for flow control.

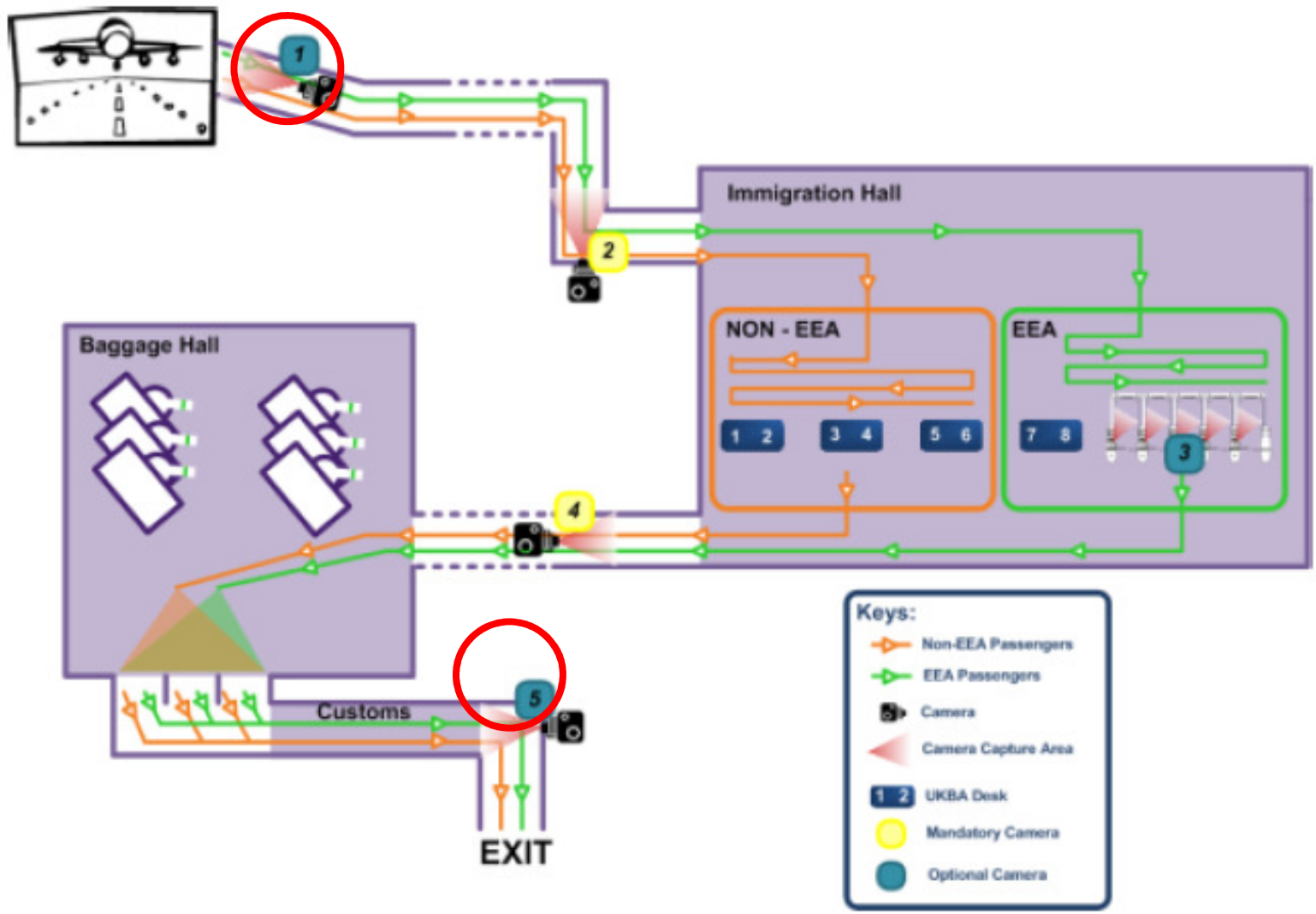
2. **Watchlist identification** is the "classic" biometric challenge, and a long-sought goal for face recognition technology. Essentially, a list of "wanted" individuals is maintained in a database, and attempts are made to capture the faces of every passing passenger, and match them against the database. Ideally, an alert should be raised for every passing passenger who is on the watchlist, and no alert should be raised for anyone else.

3. **Undocumented travelers** may seek admission to the UK and claim to have forgotten their identity and misplaced (or disposed of) their identity documents and, in some cases, request asylum. It becomes incumbent upon the authorities to help to identify from whence they came and potentially repatriate them.

4. "**Border pre-clearance**" utilizing facial recognition can automatically clear the traveller upon arrival without the need to examine the travel document again. This could be done in an Immigration "Fast-Lane" where a pre-registered traveller will simply walk through it and be identified in the process

Passive Facial Recognition

Use Case #1 - Borders



Passive Facial Recognition

Use Case #1 - Borders

	Camera ID	Position
Location A	1	**Air Bridges** – as the Passengers step outside the aircraft and walk through the jetty, their face is captured for the first time, and stored in the timing DB.
	2	**Immigration Hall Entrance** - passengers' faces are captured as they enter the Immigration Hall, giving the dwell time for transit from Gate to Hall, and enabling the calculation of time to clear Immigration.
	3	**ACS Gates** – with permission from UKBA, it would be feasible to use the photos from the ACS gates to monitor the immigration clearance time of passengers using the ACS gates compared to the overall passenger flow, without additional camera hardware being required.
	4	**Immigration Hall Exit –** passengers' faces are captured as they clear immigration, enabling the calculation of the dwell time for the immigration process (there is also the possibility to divide EEA from non EEA passengers, depending on exit routes).
Location B	5	**Arrivals Hall**– passengers' faces are captured as they exit the Customs area, enabling the calculation of the baggage retrieval / Customs process time, and the total Arrivals process time.

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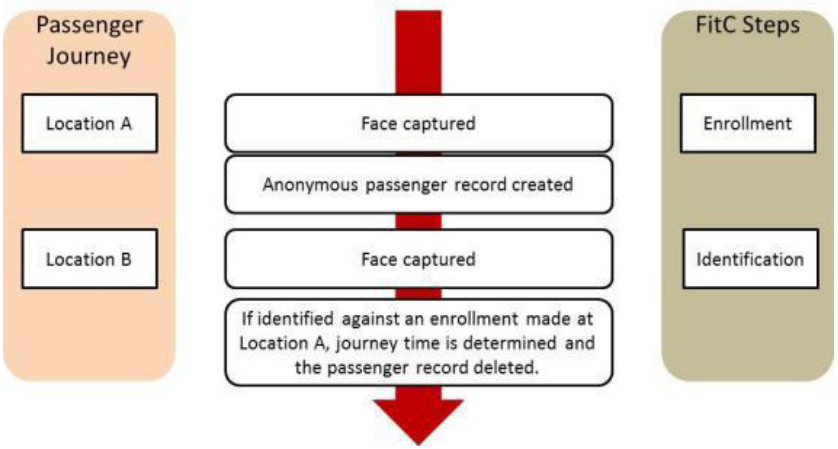
Use Case #1 - Borders

1 - Passenger Timing



If metrics of FNIR = 90%, FPIR = 2% are achieved, a Passenger Timing deployment of this system would gain correct timing information from one passenger in ten, and that would be counteracted by inaccurate timing information from one passenger in fifty.

CSF	Target	Actual
Capture Rate	≥70%	75%
FNIR	<90%	87.5% / 88.7%
FPIR	≤2%	1.4% / 0.0%

the fraction of all passing individuals that will be incorrectly matched against a different individual (and thus give incorrect timings).

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Use Case #1 - Borders

2 - Face Watchlisting

If metrics of FNIR = 30%, FPIR = 1% are achieved, a Face Watchlisting deployment of this system would, using LHR metrics, give ~630 false alerts per day (below one every five minutes, per terminal). It is proposed that this would be acceptable for a production system.

CSF	Target	Actual
Capture Rate	≥70%	78%
FNIR	<30%	30.8%
FPIR	≤1%	0.8%

the fraction of all captured individuals that are not on the watchlist, but are incorrectly identified as being so

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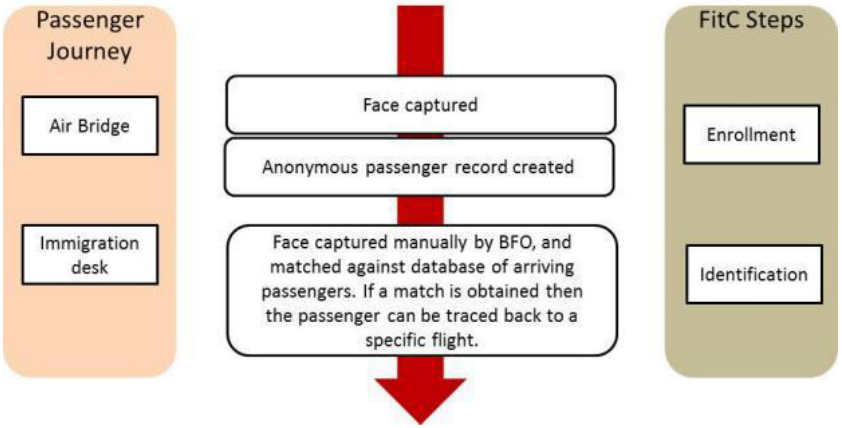
Use Case #1 - Borders

3 - Forgotten Origin



CSF	Target	Actual
Capture Rate	≥70%	78%
FNIR	≤10%	0%
FPIR	≤1%	0%

If metrics of FNIR = 10%, FPIR = 1% are achieved, an Undocumented Passenger Identification deployment of this system would correctly identify the air bridge that an arriving passenger used better than one time in two (70% x 90%), and would incorrectly identify the air bridge (or fail to enrol them) about one time in three (incorrect matches: 70% x 1%; plus failed captures of 30%). Given that this would be a supplementary means of identifying the individual, it is proposed that this would be acceptable for a production system.

the fraction of individuals presenting undocumented that were previously enrolled, and are incorrectly matched against someone else's enrolled image.

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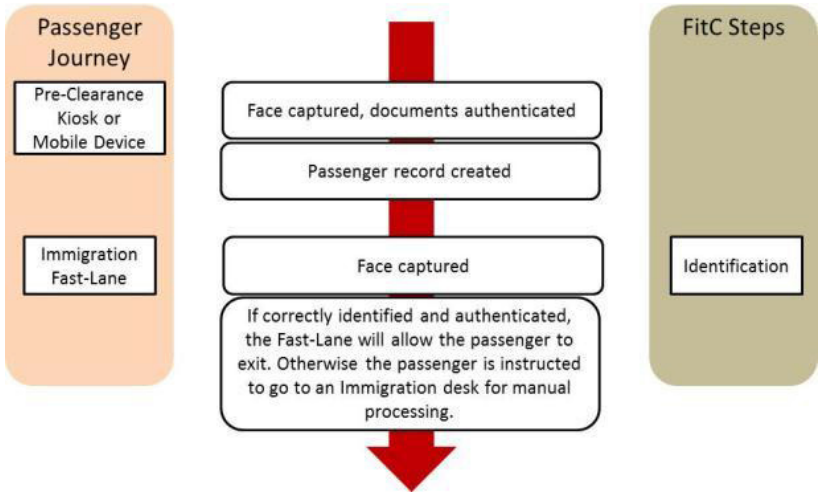
Use Case #1 - Borders

4 – Pre-Clearance



CSF	Target	Actual
Capture Rate	**≥90%**	**Did not test**
FPIR	**≤5%**	**0%**
FNIR	**≤0.5%**	**0%**

If metrics of FPIR = 5%, FNIR = 0.5% are achieved, a Border Pre-Clearance deployment of this system would correctly permit nearly 9 in 10 passengers to clear the border by "just walking". Conversely, 1 in 10 would fail to be captured by the cameras and have to visit a manual desk, with 1 in 200 potentially being accepted incorrectly through matching against another's profile.

the fraction of all captured individuals that are incorrectly matched against a different enrolled individual (and thus might pass the border without authorization).

Passive Facial Recognition

Use Case #2 - Borders

This project was undertaken to try and find out whether and to what extent face recognition is suitable for supporting the operational objectives of an unnamed EU Border Agencyto determine "**Place of origin**" and "**Early Warning**" using passive Facial Recognition

The Border Agency recruited 106 volunteers to act as test persons during the pilot project. **No operational actions were carried out in the test environment**. Five to seven enrolment photos were taken of each test person, at angles of **+30, +20, +10, -10, -20 and -30 degrees. A frontal photo** of each test person completed the series of photos. The participants then each entered these photographs into their own Early Warning databases. In addition, these images were also used as input for the "place of origin" objective.

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Use Case #2 - Borders

Place of Origin *similar to Forgotten Origin from Use Case #1 above*
The operational objective of "Place of origin" encompasses establishing the country of origin of undocumented passengers as referred to in Section 4 of the Aliens Act.

To provide support in establishing the place of origin of undocumented passengers, i.e., passengers who have reported to the Border Control Brigade and who do not possess proof of identity.

For this Place of Origin application, a reference photo of the face of the passenger in question will be used as the basis for a search through a stored set of video sequences or photos with the aim of spotting that person. The reference photo will be taken after arrival of the passenger and will be provided by the Border Agency. The video is produced by the test set-up provided by the supplier, or participant.

Early Warning - *similar to Face Watchlisting from Use Case #1 above*
The operational objective of "Early Warning" concerns generating a warning when a passenger featuring on a so-called watch list is recognized.

To provide support in the real-time identification of persons on a watch list, upon their arrival at the gate. The Early Warning application is based on real-time matching of faces detected in video sequences with a limited set of stored images in a database.

Place of Origin - Participant A

These 51 measurement points involved:
- 41 different test persons;
- 33 test persons joined the passenger flow at the Passenger Bridge once;
- 8 test persons joined the passenger flow at Passenger Bridge twice;
- 1 test person joined the passenger flow at Passenger Bridge three times

Rank	TPIR (R,20) *Frontal*	TPIR (R,20) *Frontal/ +/-10°*
1	0.30	0.39
5	0.42	0.53
10	0.44	0.55
15	0.50	0.65
20	0.58	0.69
25	0.60	0.73
30	0.60	0.75
35	0.68	0.75
40	0.68	0.75
45	0.68	0.75
50	0.70	0.78

Angle of image	TPIR (50,20)
+30°	0.15
-30°	0.28
+20°	0.30
-20°	0.42
+10°	0.47
-10°	0.53
Frontal	0.70

Passive Facial Recognition

Use Case #2 - Borders

Place of Origin - Participant B

During the pilot project, 124 searches with images taken from an angle of 10˚ were carried out; 62 of these involved images taken from an angle of +10˚, with 62 others taken from an angle of -10. Collectively, these searches found 400 correct matches, which is 65% of the total number (616) of correct matches found. These searches represented 69% of the total number of searches (180) carried out with the system of Participant B.

Rank	TPIR (R,0) *+10˚*	TPIR (R,0) *-10˚*
1	0.68	0.68
5	0.73	0.74
10	0.73	0.74
15	0.73	0.74
20	0.73	0.74
25	0.73	0.74
30	0.73	0.76
35	0.76	0.76
40	0.76	0.77
45	0.76	0.77
50	0.76	0.77

Frontal

Rank	TPIR (R,0)
1	0.70
5	0.75
10	0.77
15	0.77
20	0.77
25	0.77
30	0.80
35	0.80
40	0.80
45	0.80
50	0.80

	All Views Individually	**All Views Combined**
Rank	TPIR (R,0) *Per individual search*	TPIR (R,0) *Per test person*
1	0.68	0.74
5	0.74	0.76
10	0.74	0.76
15	0.74	0.76
20	0.74	0.76
25	0.74	0.76
30	0.76	0.79
35	0.77	0.81
40	0.78	0.81
45	0.78	0.81
50	0.78	0.81

Passive Facial Recognition

Use Case #3 - Retail

The objective of this Trial was to deploy a basic Passive FR system in a UK Shopping Centre environment to gain a better-understanding of the capabilities of the solution and to assess its potential for use in various business scenarios:

- To prove that a basic solution would capture and match individuals within a live retail environment – demonstrated through capture rates, alerting and watchlist management capabilities;
- To prove that a basic solution can operate successfully within the shopping centre's existing technical and physical infrastructure;
- To prove that shopping centre security staff could be successfully trained on the basic solution, the systems uses and functionality, and enhance the understanding of the software's benefits.

Passive Facial Recognition

Use Case #3 - Retail

- The required power and networking provision was confirmed as being met at this site;
- **The installation** approach was shown to be both **simple and quick**, and therefore a continuation of this working model will greatly simplify and expedite the deployment process (the trial camera was installed and configured in less than 3 hours);
- The physical installation was proven to be **unobtrusive and acceptable** to the client

Passive Facial Recognition

Use Case #3 - Retail

On average more than 15,000 customers a day were captured at the trial location by the single camera;

Up to 10 faces per frame (in a single camera shot) have been detected during the trial. This is important considering the peak between 1pm and 5pm where the customers detected on the escalator every 10 minutes increases from 200 to 450;

Manual counting of customers showed that on average, **92% of people using the escalator presented a visible face to the camera** at some point. The remaining 8% were usually showing their back, putting their head outside of the escalator, having their face covered, being overexposed, or presenting very strong lateral illumination;

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Use Case #3 - Retail

Given the customer's posture and movements, **in 74% of cases it was possible to acquire at least one frame usable for facial recognition**. Capture quality is the result of both the camera positioning (where people typically direct their view) and the ability of the solution to adjust gain and exposure according to the illumination of the face;

The **False Alarm Rate** (being the fraction of all captured individuals that are not on the watchlist, but are incorrectly identified as being so) **experienced was 0.05%, resulting in 5 false alarms raised every 10,000 customers** transiting by the camera. This number is considered to be at the low end scale for this type of system and would result in minimal operational work to clear the false alerts;

The **True Alarm Rate measured** (being the fraction of captured individuals that are on the watchlist and are correctly identified as such) **was above 85%.**

Passive Facial Recognition

Use Case #4 - Gambling

Objectives:

1. Investigate feasibility of using current CCTV video feeds for video analytics

2. Prove feasibility of face recognition video analytics ahead of possible broader deployment for:

    - Marketing insights
        - Detect customer gender, age, ethnicity and correlate with counter transactions
        - **Identify repeat customers (matching faces against previous customers)**

    - Security
        - **Identify customers in blacklist**

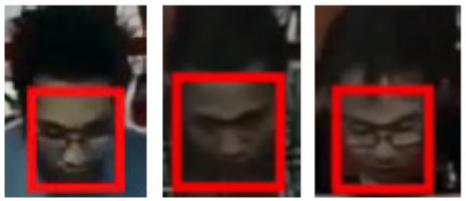
Passive Facial Recognition

Use Case #4 - Gambling

Singapore Pools Main Branch – with existing surveillance camera

* Note: demographics accuracy was calculated based on 50 sampled customers, comparing with human-observed values.

- Resolution: 704*480 (0.3MP)
- Angle of camera: ~ 50 degrees and people looking down, hence face angle is ~60-70 degrees
- Pixels between the eyes: ~25-35



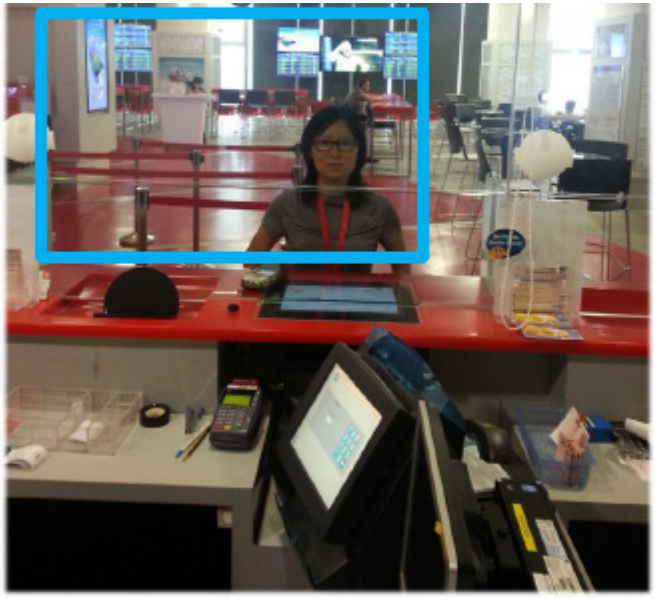
- Capture rate: 92%
- Face matching not reliable (min 60 pixels between the eyes, max 20 degrees from frontal)
- Demographics accuracy*:
  - Gender = **65.3%**
  - Age = **78.2%**
    i.e. 21.7% (within range) and 56.5% (+/- 5 years)
  - Ethnicity = **58.7%**
- Conclusion – existing camera setup (position) not suitable for face matching, demographics analytics could be used as an indicator but not very accurate.

Passive Facial Recognition

Use Case #4 - Gambling

Dedicated camera:

- Resolution: 1600*1200 (2MP)
- Angle of camera: ~ 0 degrees (about 10 degrees horizontally) and people looking down, hence face angle is ~10-20 degrees
- Pixels between the eyes: ~120-140



Camera Point of View
(blue box)

Side View of Actual Setup

Customer Point of View

Passive Facial Recognition

Use Case #4 - Gambling

Existing Surveillance Footage

Snapshots From Dedicated Camera

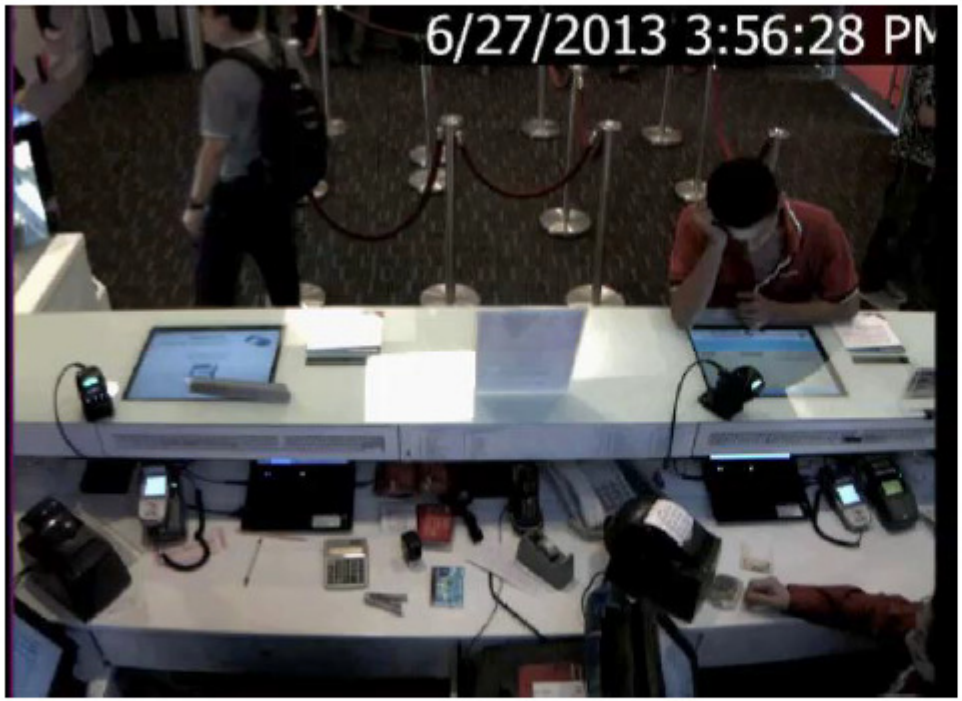
1) 100% face capture of customers.

2) 95% automated correlation with transactions (using transaction timestamp and face matching) and 5% manual correlation.

Passive Facial Recognition

Use Case #4 - Gambling

Marina Bay Sands



* Note: lower capture rate than at Main Branch due to laptop used which couldn't process all video frames – can be improved with tuning, zone of interest etc. – capture rate expected to exceed 92%. Demographics accuracy was calculated based on 50 sampled customers, comparing with human-observed values.

- **Resolution: 2048*1536 (3MP)**
- **Angle of camera: ~ 40 degrees and people looking down, hence face angle is ~50-60 degrees**
- **Pixels between the eyes: ~50-60**

- **Capture rate: 84%***
- **Face matching not reliable (min 60 pixels between the eyes, max 20 degrees from frontal)**
- **Demographics accuracy*:**
  - Gender = **74.4 %**
  - Age = **44.1%**
    i.e. 13.9% (within range) and 30.2% (+/- 5 years)
  - Ethnicity = **37.2%**
- **Conclusion – existing camera setup (position) not suitable for face matching, demographics analytics could be used as an indicator but not very accurate.**

Passive Facial Recognition

Use Case #4 - Gambling

Passive Facial Recognition

Use Case #4

When Threshold Score = 32,

- True Identification Rate = 100%
- False Match Rate (i.e. system incorrectly identify a customer as a match in the watchlist) = 2.2%

When Threshold Score = 42,

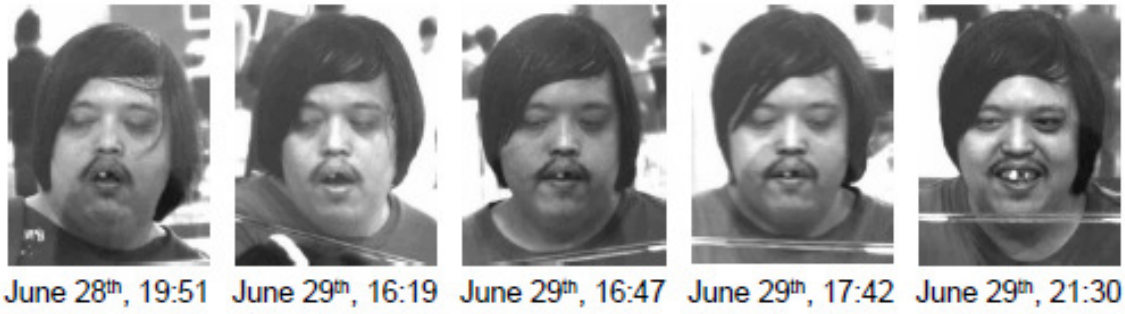
- True Identification Rate = 93.9%
- False Match Rate = 0

**Note: False Match Rate was calculated based on 224 identifications.*

Passive Facial Recognition

Use Case #4

Examples of identified repeat customers:


June 28th, 19:51 June 29th, 16:19 June 29th, 16:47 June 29th, 17:42 June 29th, 21:30


June 28th, 19:48 June 29th, 17:41 June 29th, 17:48 June 29th, 20:36


June 27th, 18:58 June 29th, 19:41 June 29th, 19:51

ISO 30137 consists of the following parts, under the general title: Information technology – **Use of biometrics in video surveillance systems**

- *Part 1: Design and specification (3rd Working Draft)*
- *Part 2: Performance testing and reporting*
- *Part 3: Data Formats*

Scope *(partial)*

- defines the key terms for use in the specification of AFR in video surveillance systems, including **metrics for defining performance**;

- provides guidance on **selection of camera types, placement of cameras, image specification**, etc., for operation of a face recognition capability;

- provides **guidance on the composition of the gallery** (or watchlist) against which facial images from the video surveillance system are compared, including the selection of appropriate images of sufficient quality, and the size of the gallery in relation to performance requirements;

Passive Facial Recognition

Conclusion

Passive (unconstrained) Facial recognition is impacted by:

- **Pose / Occlusions**
- **Lighting**
- **Resolution**

We can also see promising results with **basic technology**, minor **infrastructure modifications**, and little impact to **existing process**

We can expect Passive Facial Recognition performance improvement by altering any/all of these

Passive Facial Recognition

Thank You

INTERNATIONAL BIOMETRIC PERFORMANCE CONFERENCE
Evaluation and Performance of Biometric Technologies

May 3 – 5, 2016: Gaithersburg, MD

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